Biofuels and Bioenergy on U.S. Military Bases

Energy & Environmental Research Center
University of North Dakota

et-Zero Energy - Two-Day Workshop
Colorado Springs, Colorado
Chris J. Zygarlicke

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Presentation Outline

- Background
- Feasible biomass feedstocks
- Emerging Technologies
- Modular systems
- Advances in alternative distributed fuels and energy

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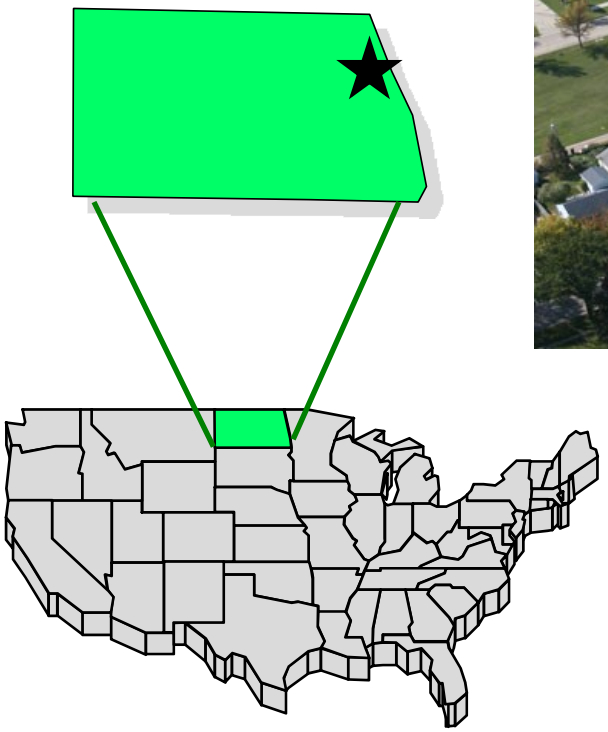

On the campus of the University of North Dakota in Grand Forks, North Dakota

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Renewable Energy and Fuels to Replace, in Part, Fossil Sources

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Feasible Biomass Feedstocks

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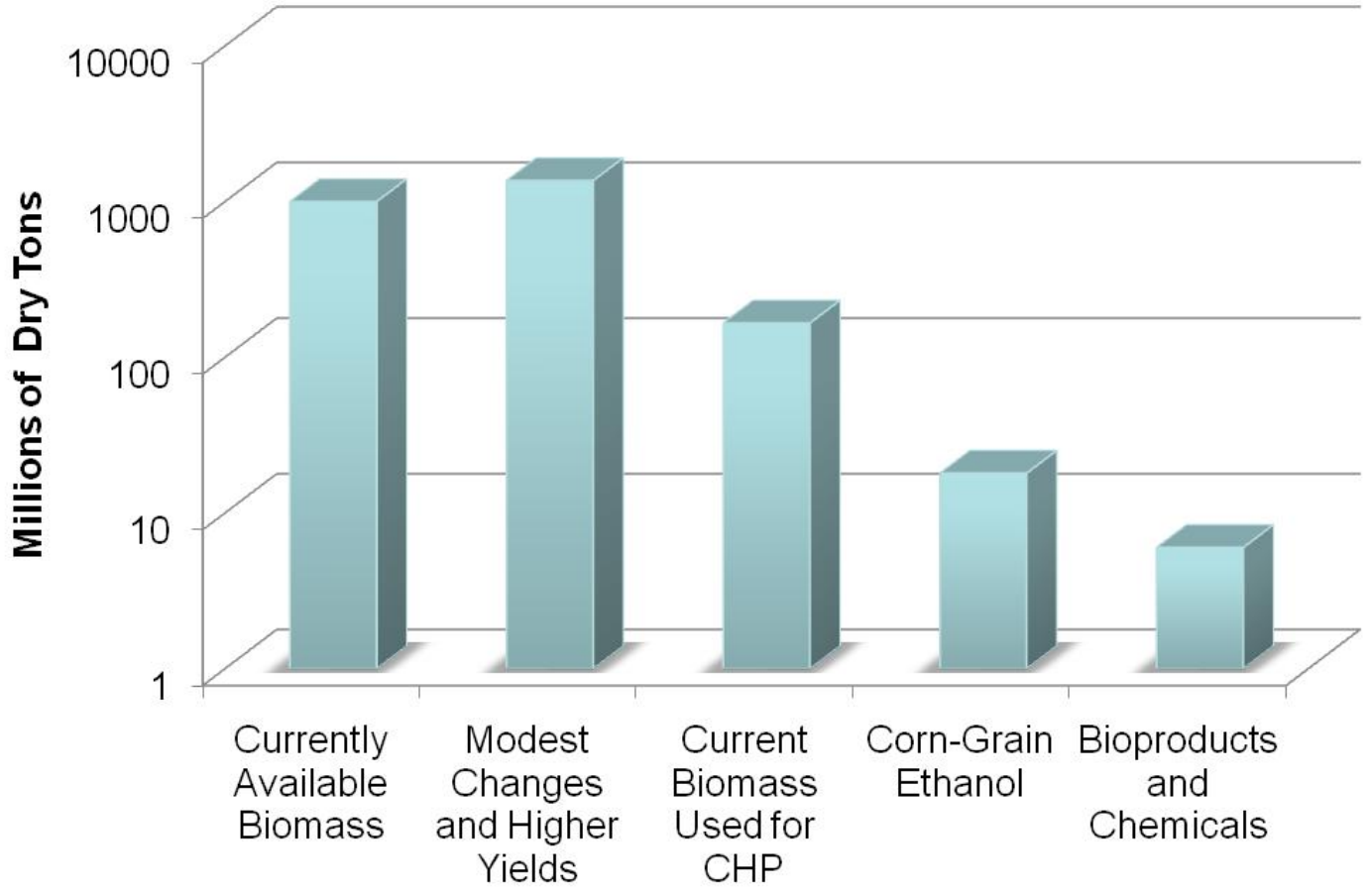
Projected Biomass Availability in the United States



U.S. Department of Energy. 2006. *Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda*, DOE/SC-0095, (www. Doegenomestolife.org/biofuels/).

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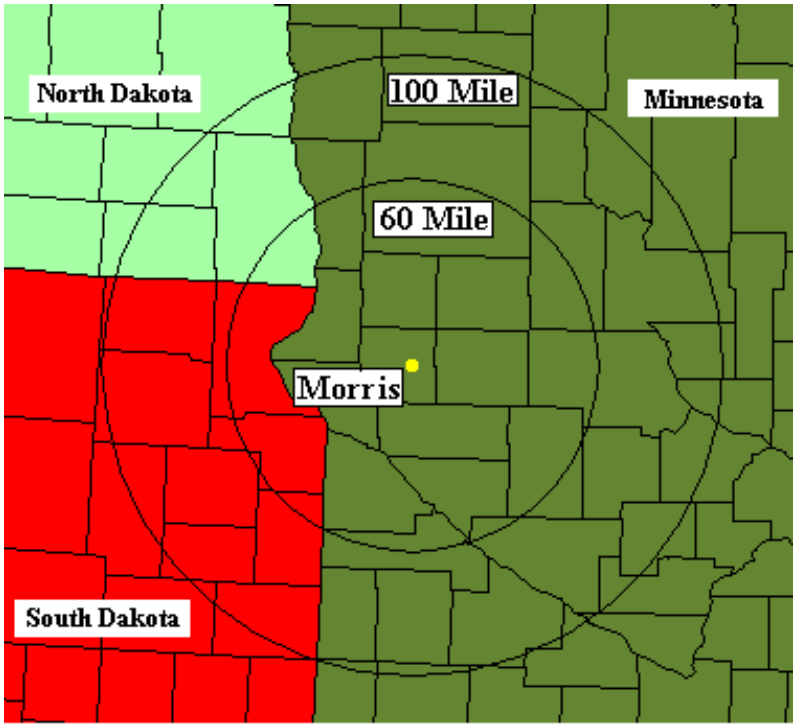
Biomass Resource Assessment

- Determine biomass feedstock types
- Quantify biomass within base confines and surrounding ***community***
- Typical scenario for small Midwestern town
  - Theoretical = 15 M tons/yr
  - Actual = 677,000 tons/yr
  - Contractual = 45,000 tons/yr
  - For this case, needed 7000 tons/yr of various types



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Feasible Biomass Feedstocks for Military Bases

- Feasible on-site
  - Municipal solid waste (MSW)
    - Also refuse-derived fuel
    - Acidified biosolids
  - Wood residues
  - Waste oils
- Agricultural residues
- Energy crops: grasses, hybrid trees, and algae

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Municipal Solid Waste

- Food wastes and garbage
- Paper materials
- Textiles
- Extensive wood materials
- Various liquids
- **Recycled**: glass and metal, batteries, etc.

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Wood Residues

- Forest thinnings
- Municipal residues
- Manufacturing residues
- Pulp and paper materials
- Sawdust, demolition wood, crates, pellets, and railroad ties

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Agricultural Residues

- Straws: rice, wheat, flax straw, alfalfa
- Potato/sugar beet and other residues
- Corn stover
- Sugarcane bagasse
- Nutshells, husks, hulls, pits
- Grape pumice (grape pumice: stems, skins, and seeds left over from pressing the grapes)
- Animal manures

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Energy Crops

- Hybrid willows and poplars
- Switchgrass or mixed prairie grass
- Algae

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Emerging Technologies

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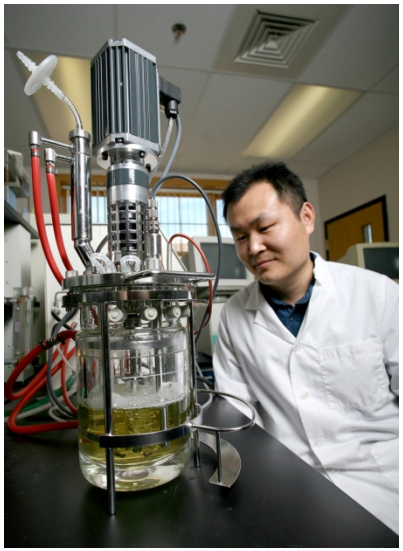
Biomass to Biofuels Technologies

- Emerging technologies
  1. **Thermal** – heat and catalysts to gasify (very little O_2) or pyrolyze (some O_2) biomass to a syngas or bio-oil; subsequent conversion of crop oil, syngas, or bio-oil to ethanol, butanol, methanol, FT liquids, JP-8, or other high-value chemicals.
  2. **Fermentation** – pretreatment of dilute or concentrated acid hydrolysis or various enzymatic and physical (i.e., steam) pretreatments.



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Needed Fuels on Military Bases or Base Camps

- ***Estimates***
  - Fuel usage varies widely :
    - JP-8: 10–15,000,000 gallons/yr
    - Gasoline: 1–2,000,000 gallons/yr
    - No. 2 diesel: 2–4,000,000 gallons/yr
    - No. 1 diesel: 1–2,000,000 gallons/yr
  - DOE Models
    - 2000 tons per day cellulosic biomass
    - 50–100 million gallons per year of biofuel

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Modular Systems

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Modular Gasifier Systems

- Use entire hydrocarbon structure (biomass, MSW, etc.)
- Match for biomass availability
- Integrated base-loaded energy and heat
- Lower operating cost
- No off-the-shelf small boilers
- Remote systems
- More tolerant of contaminants
- Low water consumption
- No pressure boiler parts or training

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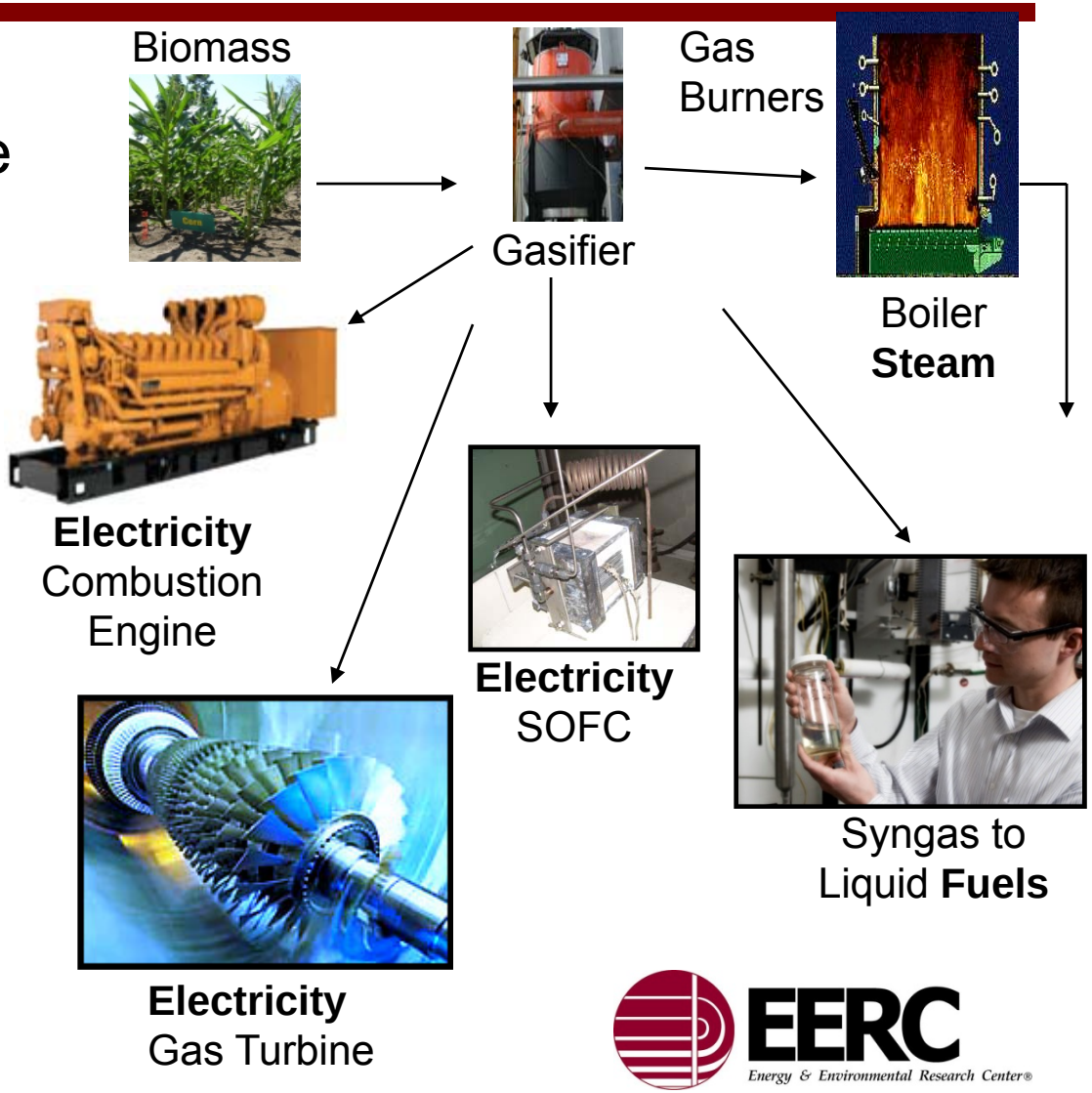
Distributed or Modular Gasifier Applications

- Boiler add-on to save solid fuel maintenance or offset natural gas
- Other natural gas offsets such as grain drying
- Power generation
- Potential syngas products via catalysis and condensation



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Status of Modular or Distributed Gasifier Systems

- Maturity: demonstration systems in the field now
- Barriers: reliability of resource, fuel handling, tar disposal or reuse, little experience for MSW or biosolids, no current “turnkey” system to model.
- Status of R&D to overcome barriers
  - The EERC has three 100-kW systems (electrical) in the field, gaining experience.
  - Need lower capital and increased simple automation.
  - More testing being done on biomass varieties.

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Advances in Alternative Distributed Fuels and Energy

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Advanced Biofuels

- Renewable fuels standard (RFS):
  - 36 billion gallons in 2022
  - 21 billion gallons needs to be of advanced biofuels
- U.S. biofuel production:
  - 450 million gallons of biodiesel (1/1/08–9/30/08)
  - 11 billion gallons of ethanol
- Biodiesel and ethanol are not considered advanced biofuels under the RFS.
- Very limited quantities of advanced biofuels are generated.

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Renewable Jet and Diesel Fuels

- The U.S. Department of Defense aims to acquire 325 million gallons of synthetic JP-8 by 2016.
- Advanced biofuels consisting of renewable jet and diesel may be achievable at military bases.
- The commercial aviation market consumes 19 billion gallons of jet fuel per year. Interested in renewable fuels but not at a premium price.

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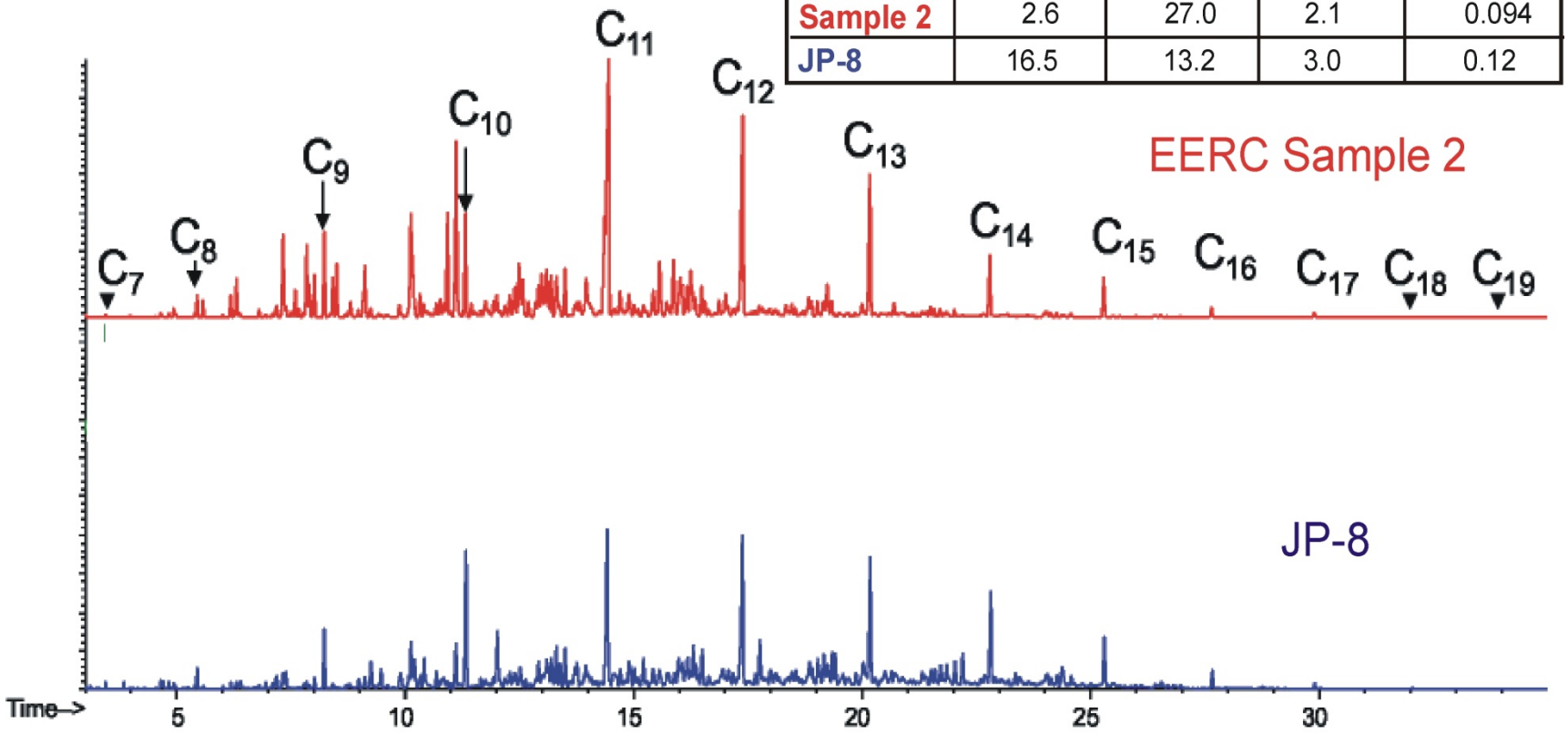
EERC Renewable JP-8 vs. Petroleum JP-8

Specification Test	EERC JP-8	JP-8 Avg.	JP-8 Spec
Aromatics, vol%	19.8	17.9	≤25.0
Olefins, vol%	1.9	0.8	≤5.0?
Specific Gravity	0.805	0.803	0.775–0.840
Flash Point, °C	49	49	≥38
Freeze Point, °C	−52	−51.5	≤−47
Heat of Combustion, MJ/kg	42.9	43.2	≥42.8

Composition Comparison – EERC JP-8 vs. Petroleum JP-8

EERC TA31442.CDR

Weight % n-Paraffins				
	C_{7}-C_{9}	C_{10}-C_{13}	C_{14}-C_{16}	C_{17}-C_{19}
Sample 2	2.6	27.0	2.1	0.094
JP-8	16.5	13.2	3.0	0.12



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Status of Renewable Biofuels

- Maturity: 1 year for niche DG; 2-5 years for refinery biofuels production; 5+ years for smaller military sites.
- Barriers: feedstock sustainability and quality; capital costs; and market prices.
- Status of R&D to overcome barriers
  - The EERC has developed 100% bio-derived JP-8 specification-compliant hydrocarbon fuel.
  - 100% bio-derived synthetic paraffinic kerosene (SPK) specification-compliant hydrocarbon fuel.
  - Next step is large-scale pilot production.
  - Renewable jet and diesel blends require testing.

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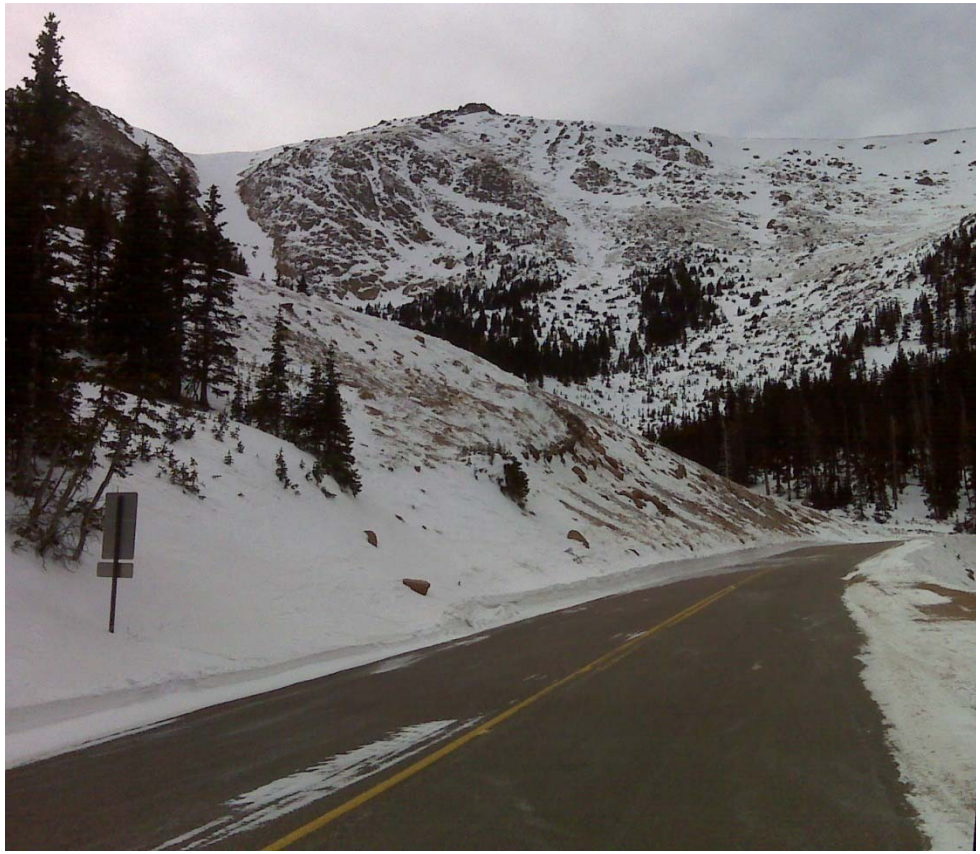
So What is Down the Road?

- Biomass feedstocks and sustainability
- Small distributed energy systems
- Advanced biofuels



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Conclusions

- Biomass feedstocks, such as MSW, waste oils, wood residues, and local agricultural residues may provide a source, but probably not sustainable beyond 20%–30% of energy needs.
- Modular or small distributed energy systems are available in demonstration-limited commercial capacity but still need fine-tuning for varieties of biomass.
- Advanced biofuel production from local biomass sources is possible, but smaller bases will have high costs.

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